FY02 Highlights

- Overview
- Architecture Concepts
- Exploration Hurdles
  - Space Transportation
  - Power
  - Crew Health and Safety
  - Human and Robotic Operations
  - Space Systems
- Technology Planning
- *Leveraging and Partnering*
- Future Direction

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Leveraging and Partnering

The NEXT strategy includes leveraging and partnership opportunities to benefit from the interests, skills and resources of others.

- NASA Initiatives
  - Nuclear Systems Initiative
  - Radiation Research Initiative
- NASA – Other Programs
  - Bioastronautics
  - Revolutionary Aerospace Systems Concepts (RASC)
  - NASA Institute for Advanced Concepts (NIAC)
- Interagency
  - NEXT proposals submitted to DOD
- Universities
  - Approximately 20 grants and contracts
- International
  - International Science and Technology Center Project 2120

Leveraging & Partnering –
Radiation Research Initiative – Challenges and strategies are coordinated with the NEXT

Humans engaged in space activities are exposed to extraterrestrial radiation, consisting of protons and heavier charged particles. Doses and dose rates typical of those caused by solar disturbances may impair crew performance whereas doses and dose rates typical of the galactic cosmic ray environment are likely to result in longer term effects, most notably an increase in the probability of cancer induction. The goal of this program is to develop the scientific basis for the protection of human crew members from space radiation. The research will guide the design of spacecraft and planetary habitats for long-term human space exploration.

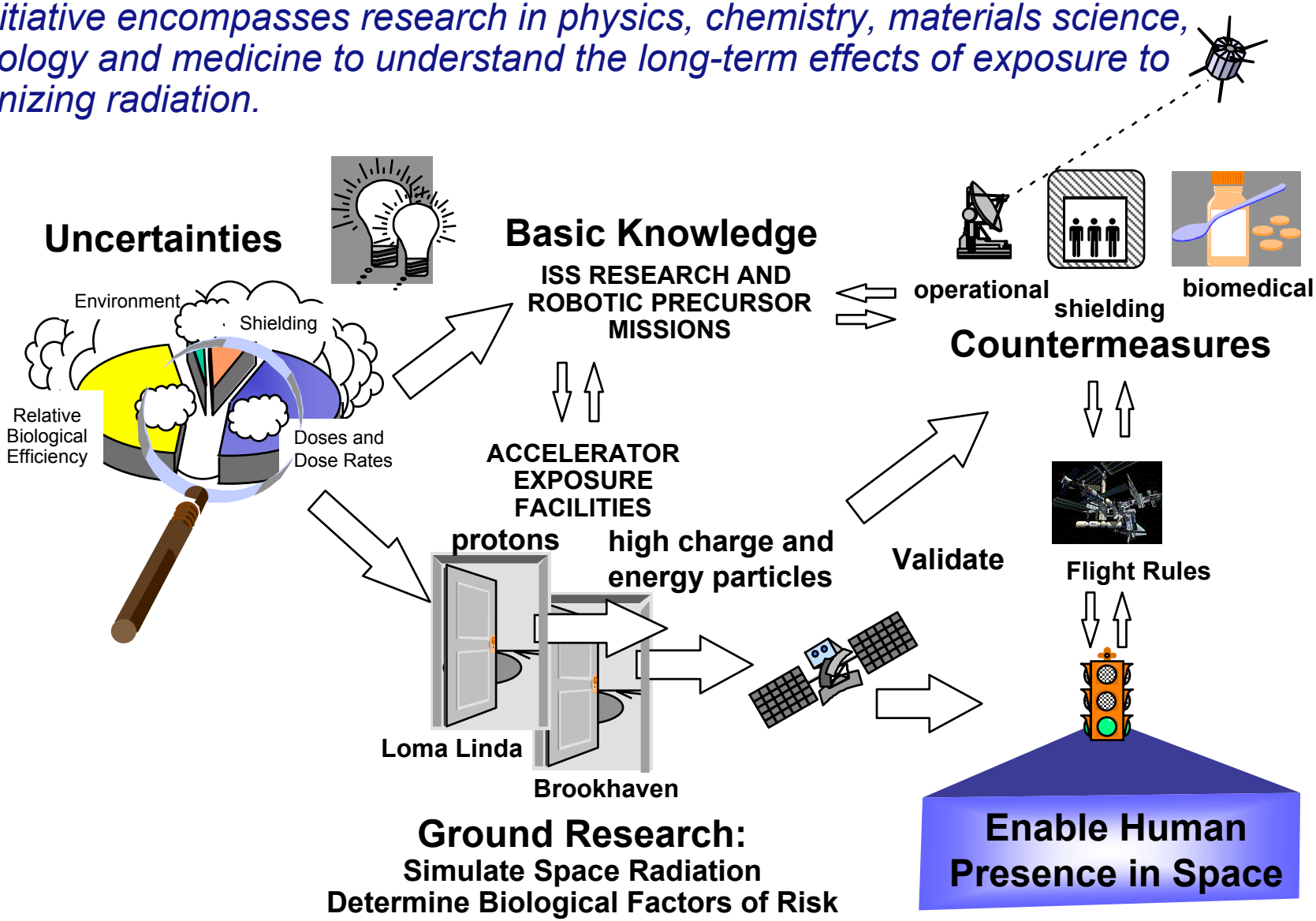
The program encompasses research in physics, chemistry, materials science, biology and medicine. It supports scientific research in three areas: the fundamental mechanisms of radiation effects on living systems and the interaction of radiation with cells, tissues and organs; the development of instruments and processes dealing with the measurement of radiation and its effects; and the development of models to predict and describe the physics of the interactions of high energy charged particles and matter. The ground-based component of the program develops scientific bases for the prediction of risk which can be tested in limited ways in ground-based facilities, but ultimately the space-based component of the program will use flight opportunities to validate models of the space environment and transport of radiation through shielding, assessment of the efficacy of ground-based experiments for predicting risk, testing of countermeasures, and understanding the synergism between the effects of radiation and other spaceflight factors such as weightlessness.

The Office of Biological and Physical Research is responsible for this initiative, which will be folded into the current Space Radiation Program. The Program will expand its research support to particular NASA Centers, universities, Department of Energy National Laboratories, and other Federal agencies.

Through numerous mission studies, NEXT has recognized the risks space radiation poses for crews going beyond LEO. NEXT, and its predecessor DPT, provided seed funding towards critical radiation analyses, particularly in the area of shielding materials, active shielding methodologies, and modeling environments and spacecraft. These studies helped to form the content and direction of the Radiation Research Initiative. The leadership of the NEXT Humans as a Subsystem Working Group are also the originators of the Radiation Research Initiative.

Radiation Research Initiative – Challenges and strategies are coordinated with the NEXT

Initiative encompasses research in physics, chemistry, materials science, biology and medicine to understand the long-term effects of exposure to ionizing radiation.



Leveraging & Partnering – Nuclear Systems Initiative and NEXT Collaboration

In parallel with the start of the Nuclear Systems Initiative, NEXT studies have highlighted the space exploration benefits inherent in nuclear systems designed to provide electrical power and propulsion for in-space transportation systems. Key findings of NEXT analysis include:

Nuclear power and propulsion are key enablers of expanded human exploration:

- Provides abundant power at destination
- Enables complex, long duration missions
- Provides high power for potential protection against charged particles
- Enables efficient in-space propulsion for human missions

Nuclear surface power is essential for extended reconnaissance of the Martian surface since it is required for:

- Long-range surface and sub-surface exploration
- Human habitat and life support
- In-situ manufacturing of consumables
- In-situ propellant production

There is an ongoing iterative process between Nuclear Systems Initiative and NEXT programs for the exchange and integration of mission requirements and technology capabilities. NEXT's system assessments will identify any unique capabilities not fully addressed within the baseline Nuclear Systems Initiative that will require additional development to meet human mission needs. It is clear that a close collaboration between the Nuclear Systems Initiative and NEXT will be required as both programs are in their early development stages and continuous interactions will be necessary as space exploration plans mature.

Nuclear Systems Initiative and NEXT Collaboration

NSI

- NSI is a proposed FY03 new start
- Preliminary studies have identified initial revolutionary solar system exploration missions enabled by nuclear power and nuclear electric propulsion
  - Radioisotope power systems for planetary surface and deep space solar system exploration
  - Nuclear propulsion to enable revolutionary Solar System Exploration
    - Access to presently unreachable high priority science destinations
    - Multiple destinations per mission
    - Ample deep-space power for science instruments
    - Increased time at destination
- NSI planning has identified possible synergies (technology evolvability) for robotic and human exploration

Programmatic Information Exchange (POC's)

Factor human mission requirements for power and transportation into selection of technologies for development to support robotic Solar System Exploration missions

NSI technical goals and systems capability

Technology gap analysis and investment strategy to meet human mission needs

NEXT

- NEXT has identified initial human class mission requirements from current and past studies
- Identify and assess technology capability over a range of possible mission scenarios
- Be apprised of NSI technology goals and schedule
- Perform technical analyses for formulating NEXT's technology investment portfolio

Human and robotic space exploration, coupled with nuclear systems technology, has the potential for safer, richer and more robust exploration

Leveraging & Partnering –
Bioastronautics Research Contributions to NEXT Goals

The six most important questions for Bioastronautics Research are:

1. Acceptable Risk: What are the appropriate levels of risk (acceptable risk), both for the individual and for the mission, for each of the critical space-related biomedical issues (i.e., the 55 "Critical Risks")?
2. Countermeasures/Adaptation: What countermeasures and strategies are most effective for maintaining and enhancing crew health, safety, behavior, and performance during space flight?
3. Medical Care: How do we provide adequate medical care to crews before, during, and after space flight?
4. Habitation Systems: How do we provide adequate habitation systems that reliably and effectively ensure crew health and safety and enhance performance during space flight missions?
5. Crew Efficiency: How can we (1) increase the amount of crew time available for conducting scientific research and (2) ensure that the crew is as productive as possible while maintaining crew health and safety?
6. Reduced Reliance on Re-supply: How can we reduce the up mass required for logistics and expendables associated with maintaining a safe, healthy, and productive environment for the crew?

The major goal for Bioastronautics Research is that, in ten years, the human will not be a limiting factor for long-duration space flight missions. To achieve this goal, all risks must be sufficiently understood and effectively mitigated. The degree of risk acceptable to meet mission requirements must be quantified. Countermeasures for all deleterious effects associated with physiological, behavioral, and psychosocial issues encountered during space flight must be developed through interdisciplinary focused research and fully implemented in space flight operations as flight rules. The underlying mechanisms and processes must be understood wherever possible and necessary for the development of efficacious countermeasures.

Bioastronautics Research Contributions to NEXT Goals

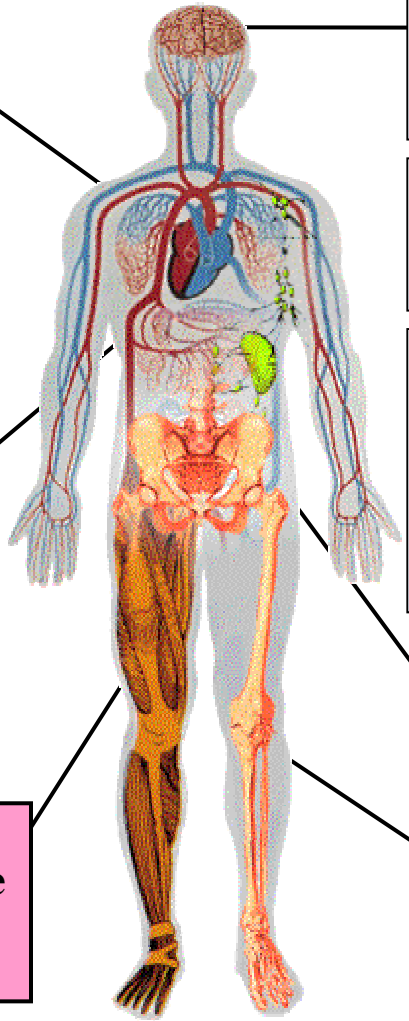
Variation in crew radiation limits and risk relative to age and sex (2001)

Red blood cell loss can be countered by erythropoietin hormone therapy (12/99)

Injected aminoguanidine may be an effective therapy for orthostatic intolerance fainting problems (12/00)

Implant releases of insulin like growth factor protein increases muscle generation and counters muscle losses (12/99)

10 minutes daily of 30-90 Hz vibration (equivalent to 1/3g) may be an effective remedy for muscle/strength decrease (11/01)



"Hardwired" mental model of gravity conflicts with hand/eye coordination of motor tasks in zero-g ball catching (2001)

Bright light therapy is an effective approach to shifting circadian rhythms

Psychological effects of long duration missions can be mitigated by training to cope with interpersonal and cultural relations between crew and ground team personnel (12/00)

Promethazine is an effective drug for space motion sickness in most crew

Resistive exercise and drugs like Alendronate or osteoprotegerin promise to address bone losses of 1-2% per month and up to 40% total loss (3/02)

Leveraging & Partnering – Revolutionary Aerospace Systems Concepts (RASC)

The key objective of the RASC Program is to look beyond current Research and Technology programs, missions, and evolutionary technology development approaches and explore, with a "top-down" perspective, possible new mission capabilities. The accomplishment of this objective will allow NASA to provide the ability to go anywhere, anytime – safely and affordably – to meet strategic goals for space exploration, science, and commercialization.

The RASC Team seeks to maximize the benefits of revolutionary capabilities that span across the Enterprises as it defines the needed technology areas and performance metrics.

The products of RASC Program studies are revolutionary systems concepts, enabling technologies, and payoffs in new mission capabilities which these concepts can provide. These results are delivered to the NASA Enterprises and the NASA Chief Technologist for use in planning revolutionary NASA research and technology program investments.

The following "top-down" approach is used in RASC studies:

- Identify with at least a 25-year vision, desired new capabilities derived from NASA Enterprise strategic objectives and priorities
- Define integrated systems approaches (architectures) and their required functional capabilities or engineering challenges
- Explore revolutionary systems concepts to provide these capabilities
- Conduct systems trade studies to define the enabling technologies and performance levels needed to meet the challenges, and
- Recommend the most promising revolutionary concepts with their integrated system payoffs and key enabling technologies.

RASC activities are closely coordinated with NEXT. For example, members of the RASC Steering Committee – the RASC leadership team which establishes study themes and selects topics for study – include members of the NEXT Management Team.

http://rasc.larc.nasa.gov/

Revolutionary Aerospace Systems Concepts (RASC)

The NASA RASC Program looks beyond current Research & Technology programs, missions, scenarios and evolutionary technology development to select revolutionary concepts to be studied as potential solutions to NASA's future requirements.

FY02 NEXT-RELATED STUDIES:

Human Robotics Exploration

- Life Detection Requirements and Revolutionary Instrument Concept Development
- Human-Robotic Exploration Advanced Concept Development using Revolutionary Aerospace Technologies
- Human-Robotic Cooperative Teams beyond Low-Earth Orbit
- Advanced In-Space Extravehicular Activity Capabilities
- Human Emplacement of Lunar Telescopes

Human Exploration of the Solar System Beyond Mars

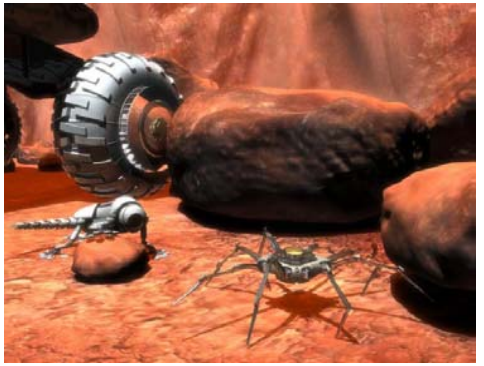
- Human Exploration of the Moons of the Outer Planets
- Central Libration Power Station for Earth Neighborhood Operations
- Multifunctional Concepts for Radiation Health Risks Mitigation
- Orbital Aggregation & Space Infrastructure Systems (OASIS)
- Fusion Propulsion
- Sustained High-Power Generation
- High Power Plasma Propulsion

In-Space Remote Sensing

- Space-Based Imaging Interferometry
- Comet and Asteroid Protection System (CAPS)
- Planetary Body Maneuvering
- Concepts to Image Black Hole Event Horizons

Tool Development

- Enhanced Europa Lander Decision Tree Model



Human-Robotic Exploration Advanced Concept Development using Revolutionary Aerospace Systems

Human Exploration of the Moons of the Outer Planets

RASC
REVOLUTIONARY AEROSPACE SYSTEMS CONCEPTS

Leveraging & Partnering –
NASA Institute for Advanced Concepts (NIAC)

The purpose of NIAC is to provide an independent, open forum for the external analysis and definition of space and aeronautics advanced concepts complementing the advanced concepts activities conducted within the NASA Enterprises.

NEXT influences NIAC in several areas. For example, NEXT team members are representatives to the NIAC. They are members of study selection committees. NIAC, funded through the Office of Aerospace Technology, also has close ties with RASC. RASC and NIAC leadership attend each other's study reviews. Such working relationships further extend the goals and vision of NEXT throughout academia and industry.

NIAC's focus is on revolutionary concepts for systems and architectures; and, functionally independent of NASA, NIAC studies are bounded only by the horizons of human imagination. Such freedom leads to the expansion of our vision of future possibilities.

NIAC also creates an additional channel for advanced concepts to respond to NASA's fundamental science questions and to augment NASA Enterprise Strategic Objectives. NIAC's goal is to develop the advanced concepts which will result in changes to the nation's future aerospace policies and plans.

Contact Information:

NIAC Director:
Dr. Robert A. Cassanova
bcass@niac.usra.edu
555A Fourteenth Street, N.W.
Atlanta, Georgia 30318
Voice: (404) 347-9633
FAX: (404) 347-9638

NIAC Associate Director:
Ms. Patricia Russell
prussell@usra.edu
(202)488-5142

http://www.niac.usra.edu/

NASA Institute for Advanced Concepts (NIAC)

NIAC provides an independent, open forum for the external analysis and definition of space and aeronautics advanced concepts which complements the advanced concepts activities conducted within NASA.

Goal:

- Develop advanced concepts which will result in changes to the nation's future aerospace policies and plans

Methods:

- Focus on revolutionary concepts for systems and architectures
- Functionally independent of NASA
- Bounded only by the horizons of human imagination
- Expand our vision of future possibilities

FY02 Study Topics which Relate to NEXT Goals:

Advanced Power
Advanced Propulsion
Aeronautics
Asteroid Detection
Astronomy
Biology
Communication
Earth Sciences
In-Situ Utilization
Life Sciences
Planetary Colonization
Robotics
Satellite Teams
Software
Space-Based Construction
Structural Systems

Leveraging & Partnering – DOD Partnering

There is a long-established tradition of interagency collaboration in science and technology practices at low levels of effectiveness. The events of 9/11 stimulated large supplements to the budgets of other agencies over and above what had been planned. NEXT engaged a strategy of mapping common science and technology interests, identifying partnering opportunities, and developing proposals that constituted campaign plans that could be funded through supplemental budget allocations. NEXT cleared the initiative through other agency personnel and complemented and supplemented the NASA on-going proposal activities.

The selected proposals provide a documented basis for inter/intra-agency partnership leading to economies, efficiencies, and effectiveness in realizing science and technology outcomes that facilitate the exploration and development of space while serving common interests across agencies.

They also provide a documented outreaching for contributing science and technology to national priority applications while addressing unfunded priorities in the development

These proposals are in the various stages being refined for submission by the NASA Centers and/or NEXT.

DOD Partnering

NEXT is pursuing funded partnerships with the DOD for the development of space technologies of interest to both agencies. NASA proposals addressing technologies of mutual interest provide the basis for interagency cooperative activities.

Proposals are being prioritized against the NEXT science and technology gap analysis and interagency funding potential based on maturity, relevance, operational impact, and cost.

Transportation:

- Synergetic Orbit Plane Changing, Increased Orbiting Assets Operability and Survivability through the use of Synergetic Plane Change and a Lightweight Inflatable Mid Lift/Drag Aeroshell
- Solar Sail Propelled Pole Sitting Satellite and Solar Sail Solar Storm Sentinels Flight Demonstration
- Electrodynamic Tether Propulsion and Electrodynamic Tether Satellite Recovery
- Electric Propulsion (including appropriate technologies like Laser Illumination for high power electric propulsion thrusters)

Crew Health and Safety

- Protective Clothing for Hazardous Operations (Next Generation SCAPE Suit), Piezoelectric Pump, Self Seal Bladder, Fuel Cell and Portable Breathing Apparatus
- Passive Neutron Detector and Small Active Dosimeter
- Protection and Assessment of Government and Civilian Resources from Ionizing Radiation

Human and Robotic Operations

- Erectable Deployment for Large High Precision High Stiffness Space Antennas
- Perimeter Defense Robot and Robots for Urban Search and Rescue and Nanoscale Robot Development
- Extremely High Dexterity Robotic System for Assisting or Replacing Humans in Hazardous Environments and Robotic "Pack Mule" for Operations

Leveraging & Partnering –
DARPA Collaboration – RescueSat Concept Feasibility Study

The Defense Advanced Research Projects Agency (DARPA) vision is to develop RescueSat technology that will enable spacecraft rescues so that they can perform their originally intended missions following specific types of failures. Ideally, in addition to providing the flexibility to rescue a wide range of spacecraft, such RescueSats could also perform a variety of other useful missions.

One key assumption, and a significant discriminator from the DARPA Orbital Express effort, is that the satellite to be rescued is not specifically designed to be rescued and/or re-positioned.

DARPA Collaboration – RescueSat Concept Feasibility Study

- **Challenge:** Most existing spacecraft were not designed for rescue and/or repositioning by another spacecraft; each of the hundreds of different types of spacecraft bus designs have unique physical and operational design characteristics. The Defense Advanced Research Projects Agency (DARPA) seeks to develop one or several generic RescueSat interfaces that address a majority of bus configurations.
- **Solution:** The focus of this task is the identification of the salient physical and detailed design features that will influence the design of one or more generic spacecraft interfaces. The generic interfaces will be suitable for enabling rescue and/or repositioning of a wide range of spacecraft not originally designed for rescue.
- **Benefit:** Potential applications for a RescueSat include: (1) re-boosting of spacecraft that are in improper orbits due to an under-performing launch vehicle, (2) moving dead satellites to an unused orbit or to a lower orbit altitude that would result in intentional re-entry of the spacecraft over a desired location on the Earth, and (3) removing orbital debris from an orbital slot.
- **Accomplishments:**
  - Evaluated relevant NASA and DOD technology and missions
  - Completed preliminary evaluation of satellite design factors for servicing
  - Identified technology capabilities and undertook gap analysis

Leveraging & Partnering – University Participation

NEXT increases its effectiveness by leveraging its resources with the resources of scientific institutes, other NASA programs, other government agencies, industry, and academia.

Such leveraging allows the team to do more with less while furthering the vision and mission of the Agency. Partnerships with like-minded organizations also allow the team to increase its effectiveness by adding to the pool of creative and innovative minds of the Agency.

Listed below are the organizational entities with which NEXT has partnered, pooled resources, or contracted with in order to achieve the group's goals and objectives. The universities have participated in a variety of activities – from defining primitive-level operations for both humans and robots to performing the analysis of radiation shielding technologies necessary to protect crew and electronics from the harmful effects of interplanetary radiation.

University Participation

- University of Washington (M2P2)
- University of Alabama, Huntsville (M2P2 Radiation Analysis)
- University of West Florida (IHMC)
- Carnegie Mellon University (Robotics State-of-the-Art and EVA Robotic Assistant)
- Old Dominion University (Radiation Analysis and Shielding)
- University of Wisconsin (Radiation Shielding)
- University of Southern California (Human-Robotic Performance Analysis)
- Simon Fraser University (Collaborative Field Exploration)
- MIT, Rice, Texas A&M University (ACT Systems Analysis, Integration and Modeling)
- Cal Tech, Purdue University (Orbital Dynamics)
- Purdue University, Arkansas Tech University (Axels Evolvable Robotics)
- Colorado School of Mines (Economic Model for Space Resource Development)
- North Carolina A&T University (Human Space Flight Institute Student Training)
- University of Texas, University of Houston, MIT (VASIMR)
- Christopher Newport University (Radiation Analysis and Shielding)
- College of William and Mary (Radiation Analysis)
- Southern Illinois University (Radiation Analysis)

Leveraging & Partnering –
International and US Cooperation and Collaboration

NASA continues to work assiduously at the goal of developing relationships with potential international collaborators and partners in future missions of human and robotic exploration and development of space.

During FY 2002, a wide range of activities was undertaken in support of this strategic purpose. These included:

- Strong participation in the World Space Congress held in Houston, Texas, in October 2002
- Leadership (with others), under the auspices of the European Space Agency, of a major study by the International Academy of Astronautics to examine options for future collaboration in the development of space systems and capabilities
- Oversight of a U.S. State Department-funded project under the management of the International Science and Technology Center (ISTC) in Moscow of a project (ISTC 2120, led by the Keldysh Research Center) to examine technical means for future interplanetary human missions
- Planning for a potential International Academy of Astronautics-ISTC jointly-sponsored conference, to be held in Moscow in Spring 2003
- Leadership (with Kobe University) of a Space Power Working Group as part of the Japan-U.S. Science, Technology and Space Applications Program (JUSTSAP), which met in November 2002
- Participation in the Annual Symposium of the International Space University (ISU), held in Strasbourg, France, in June 2002

International and US Cooperation and Collaboration

NASA continues to work assiduously at the goal of developing relationships with potential international collaborators and partners in future missions of human and robotic exploration and development of space.

- International Astronautical Federation / World Space Congress
  - October 2002
- International Academy of Astronautics (IAA) Study
  - 2000-2003
  - Key opportunity for coordination with ESA on Aurora Project, CSA, others…
- International Science and Technology Center (ISTC)
  - Project 2120 (Keldysh Research Center, others)
- IAA-ISTC Jointly Sponsored Conference (Planning)
  - Moscow, December 2002
- Japan-United States Science, Technology and Space Applications Program (JUSTSAP)
  - November 2002
- International Space University
  - Strasbourg; June 2002 Symposium

Leveraging & Partnering –
US-Russian ISTC Project 2120 and NEXT Collaboration

The International Science and Technology Center (ISTC) was formed in 1994 to maintain a focus on the nonproliferation goals of the U.S. Departments of Defense and Energy. The Center coordinates the efforts of numerous governments, international organizations, and private sector industries to provide weapons scientists from the Commonwealth of Independent States (CIS) countries with opportunities to redirect their talents toward peaceful science.

Proposals are submitted to the ISTC for competitive funding. In 2001, 280 projects received grants.

NEXT collaboration in the ISTC started in 1999 with Project 1172, "Development of Key Technical Means for Manned Planetary Missions." Following the results of 1172, the team felt that this activity was worthy of further study which resulted in the current Project 2120.

The Project 2120 team consists of members from NASA, ESA, Boeing, and personnel from various Russian organizations including:

- Keldysh Research Center
- Rocket-Space Corporation
- State Enterprise Krasnaya Zvezda
- Institute of medical and Biological Problems
- Institute of Space Research

US-Russian ISTC Project 2120 and NEXT Collaboration

- International Science and Technology Center (ISTC) Project # 2120 is a follow-on to Project #1172 "Preliminary Project of Manned Mars Expedition" completed in January 2001
- Kickoff meeting held in Moscow January 21- 24, 2002
- Study objectives
  - Use a Mars mission as a basis to determine concepts, characteristics and technologies for planetary human exploration
  - Assess and substantiate crew safety within the Mars study architecture
  - Increase cooperation between collaborators
- Key study products:
  - Mars mission element designs
    - Surface power systems
    - In-space propulsion systems and vehicles
    - Planetary landers
    - Medical and biological systems (variable gravity,radiation, etc.)
    - Mission support elements..science instruments, rovers, airships, robots, etc.)
  - Models and full-scale articles manufactured and tested

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